# Fundamentals of Oxy-Acetylene Gas Welding & Gas Cutting

## 1.0 INTRODUCTION:

Oxy-Acetylene Gas Welding (OAGW) is a welding process in which the metals are joined by heating with oxy-acetylene gas flame with or without the use of filler metal. The process involves the melting of the base metal and a filler metal, if used, by means of the flame produced at the tip of a welding torch. Acetylene gas and oxygen are mixed in the proper proportions in a mixing chamber of the welding torch.

The equipment used in OAGW is low in cost, usually portable, and versatile enough to be used for a variety of related operations, such as bending & straightening, preheating, post-heating, etc.

With relatively simple changes in equipment, manual and mechanized oxygen cutting operations can also be performed. Metals normally welded with this process include steels, especially low alloy steels, and most nonferrous metals. The process is generally not used for welding refractory or reactive metals.

## 2.0 ABOUT THE PROCESS:

The chemical action of the flame on a molten pool of metal can be altered by changing the ratio of the volume of oxygen to acetylene issuing from the tip. Most oxyacetylene welding is done with a neutral flame having approximately a 1:1 gas ratio. An oxidizing action can be obtained by increasing the oxygen flow, and a reducing action will result from increasing the acetylene flow. Both adjustments are valuable aids in welding.

The chemical reaction for a one-to-one ratio of acetylene and oxygen plus air is as follows:

$C_2H_2 + O_2 = 2CO + H_2 + \text{Heat}$

This is the primary reaction: however, both carbon monoxide and hydrogen are combustible and will react with oxygen from the air:

$2CO + H_2 + 1.50_2 = 2CO_2 + H_2O + \text{Heat}$

This is the secondary reaction which produces carbon dioxide, heat, and water.

Torches should be lighted with a friction lighter or a pilot flame. The instructions of the equipment manufacturer should be observed when adjusting operating pressures at the gas regulators and torch valves before the gases issuing from the tip are ignited.

The oxy-gas flame cutting is one of the most common methods used in cutting of metals. This process is used as a most convenient tool for steel-work, naval activities, etc for cutting of ferrous metals. This versatile tool is used for operations, such as beveling of plate & pipes, cutting, piercing holes in steel plate, and cutting wire rope.

When using the oxy-gas cutting process, first the spot is heated to the kindling or ignition temperature (between 1400°F and 1600°F for steels). The flame is called the *PREHEATING FLAME.* Next, a jet of pure oxygen is directed at the heated metal by pressing a lever on the cutting torch. The oxygen causes a chemical reaction known as *OXIDATION*.

When the oxy-gas torch is used to cut metal, the oxidation of the metal is extremely rapid and part of the metal actually burns. The heat, liberated by the burning of the iron or steel, melts the iron oxide formed by the chemical reaction and accelerates the preheating of the object you are cutting. The molten material runs off as slag, exposing more iron or steel to the oxygen jet. In oxy-gas cutting, only that portion of the metal that is in the direct path of the oxygen jet is oxidized. The narrow slit, formed in the metal as the cutting progresses, is called the *KERF.* The materials removed from the kerf are in the form of oxides (products of the oxidation reaction). The remainder of the material is molten metal that is blown or washed out of the kerf by the force of the oxygen jet. The walls of the kerf formed by oxy-gas cutting of ferrous metals should be fairly smooth and parallel to each other. Partial oxidation of the metal is a vital part of the oxy-gas cutting process. Because of this, carbon steels are easily cut but metals that do not oxidize readily (for example: Austenitic Stainless steels) are not suitable for oxy-gas cutting.

**2.1 Temperature Zones in Flames** – The welder can increase the oxygen or decrease the acetylene until the length of the inner cone is decreased to the desired amount. The temperature of the inner cone of the flame is maximum (figure-1).

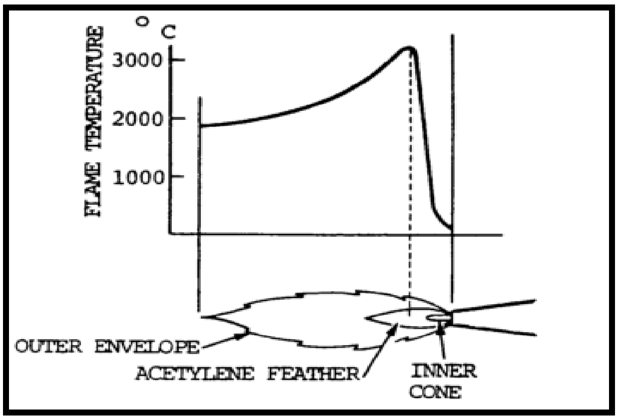


**Figure-1:** The temperature of the flame.

**<u>2.2 Types of Flames</u>** – There are three basic types of flames: neutral (balanced), excess acetylene (carburizing) & excess oxygen (oxidizing). They are shown in figure-2 to figure-4.

**2.2.1: <u>The neutral flame</u>** has a one-to-one ratio of acetylene and oxygen. It obtains additional oxygen from the air and provides complete combustion. It is generally preferred for welding. The neutral flame has a clear, well-defined, or luminous cone indicating that combustion is complete (figure-2).

In the neutral flame, the temperature at the inner cone tip is approximately 5850ºF (3232ºC), while at the end of the outer sheath or envelope the temperature drops to approximately 2300ºF (1260ºC). This variation within the flame permits some temperature control when making a weld. The position of the flame to the molten puddle can be changed, and the heat is controlled in this manner.

For a strictly neutral flame, no whitish streamers should be present at the end of the cone. In some cases, it is desirable to leave a slight acetylene streamer or "feather" 1/16 to 1/8 in. (1.6 to 3.2 mm) long at the end of the cone to ensure that the flame is not oxidizing. This flame adjustment is used for most welding operations and for preheating during cutting operations. When welding is done on steel with this flame, the molten metal puddle is quiet and clear. The metal flows easily without boiling, foaming, or sparking.

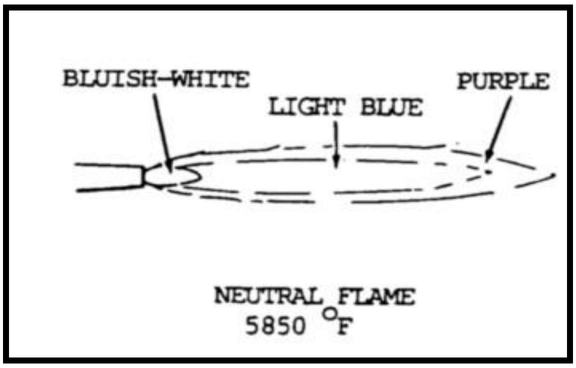


**Figure-2:** Schematic representation of Neutral flame.

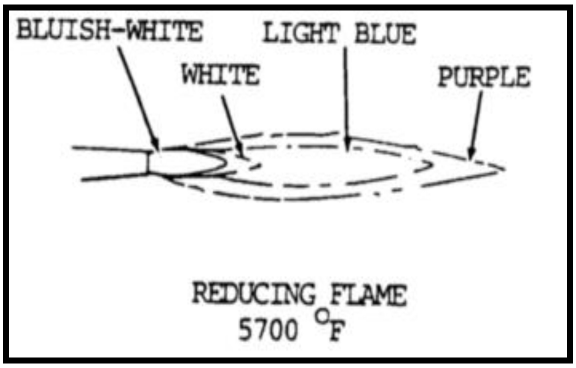


**Figure-3:** Schematic representation of Reducing/ Carburizing flame.

**2.2.2: <u>The carburizing or reducing flame</u>** has excess of acetylene. The inner cone has a feathery edge extending beyond it. This white feather is called the acetylene feather. If the acetylene feather is twice as long as the inner cone, it is known as a 2X flame - which is a way of expressing the amount of excess acetylene. The carburizing flame may add carbon to the weld metal.

The reducing or carburizing flame is obtained when slightly less than one volume of oxygen is mixed with one volume of acetylene. This flame is obtained by first adjusting to neutral and then slowly opening the acetylene valve until an acetylene streamer or "feather" is at the end of the inner cone. The length of this excess streamer indicates the degree of flame carburization. For most welding operations, this streamer should be no more than half the length of the inner cone.

The reducing or carburizing flame can always be recognized by the presence of three distinct flame zones (figure-3). There is a clearly defined bluish-white inner cone, white intermediate cone indicating the amount of excess acetylene, and a light blue outer flare envelope. This type of flare burns with a coarse rushing sound. It has a temperature of approximately 5700ºF (3149ºC) at the inner cone tips.

When a strongly carburizing flame is used for welding, the metal boils and is not clear. The steel, which is absorbing carbon from the flame, gives off heat. This causes the metal to boil. When cold, the weld has the properties of high carbon steel, being brittle and subject to cracking.

A slight feather flame of acetylene is sometimes used for back-hand welding. A carburizing flame is advantageous for welding high carbon steel and hard facing such nonferrous alloys as nickel and Monel. When used in silver solder and soft solder operations, only the intermediate and outer flame cones are used. They impart a low temperature soaking heat to the parts being soldered.

**2.2.3: The oxidizing flame** has an excess of oxygen, has a shorter envelope and a small pointed white cone. The reduction in length of the inner core is a measure of excess oxygen. This flame tends to oxidize the weld metal and is used only for welding specific metals.

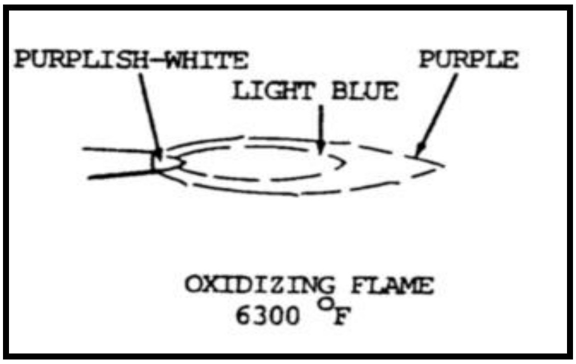


**Figure-4:** Schematic representation of Oxidizing flame.

The oxidizing flame is produced when slightly more than one volume of oxygen is mixed with one volume of acetylene. To obtain this type of flame, the torch should first be adjusted to a neutral flame. The flow of oxygen is then increased until the inner cone is shortened to about one-tenth of its original length. When the flame is properly adjusted, the inner cone is pointed and slightly purple (figure-4). An oxidizing flame can also be recognized by its distinct hissing sound. The temperature of this flame is approximately 6300ºF (3482ºC) at the tip of the inner cone.

When applied to steel, an oxidizing flame causes the molten metal to foam and give off sparks. This indicates that the excess oxygen is combining with the steel and burning it. An oxidizing flame should not be used for welding steel because the deposited metal will be porous, oxidized, and brittle. This flame will ruin most metals and should be avoided. Slightly oxidizing flame is used in torch brazing of steel and cast iron. A stronger oxidizing flame is used in the welding of brass or bronze.

The amount of excess oxygen used in this flame must be determined by observing the action of the flame on the molten metal.

**2.3 Equipment for the Process** – The equipment consists of a cylinder of acetylene, a cylinder of oxygen, two regulators, two lengths of hose with fittings and a cutting torch with tips. The equipment is schematically shown in figure-5.

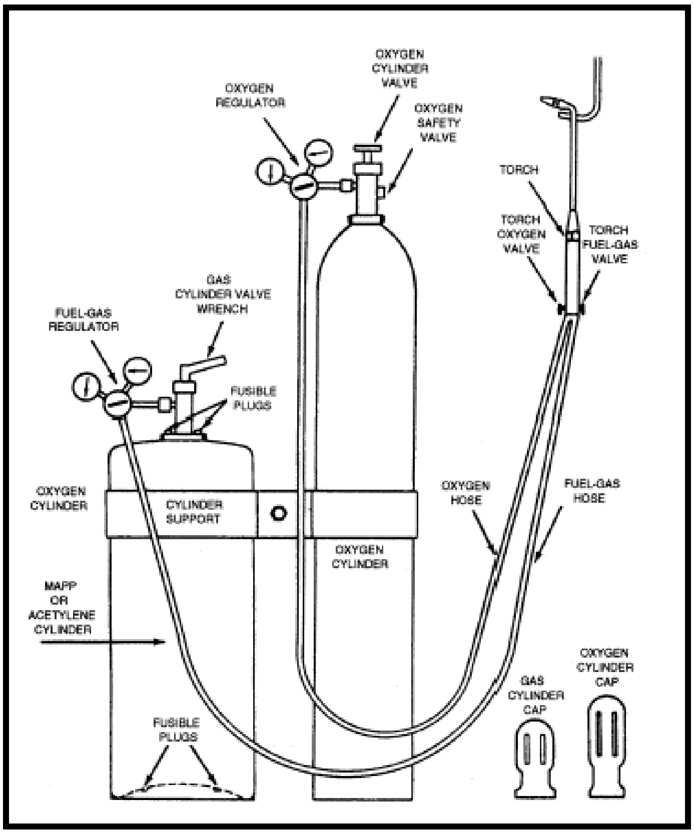


**Figure-5:** Schematic representation of gas welding/ cutting equipment.

The torch (figure-6) and the mixing of the gases (figure-7) inside the torch are shown in the figure below.

**Figure-6:** Gas welding torch.

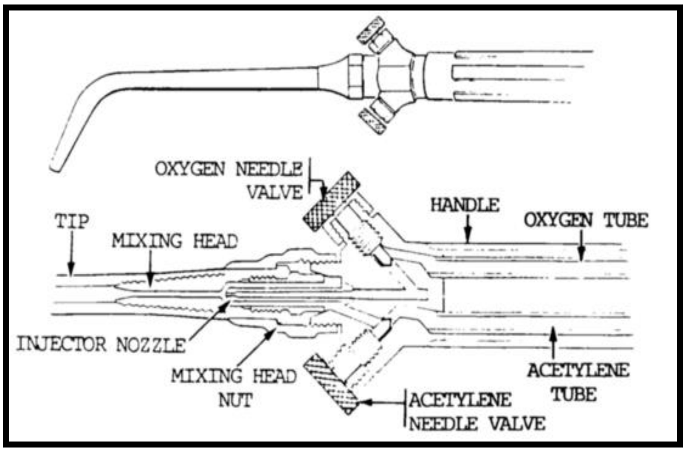


**Figure-7:** Schematic representation of mixing-head for welding torch.

**2.4 Lighting the Torch** –

1. To start the welding torch, hold it so as to direct the flame away from the operator, gas cylinders, hose, or any flammable material. Open the acetylene torch valve 1/4-turn and ignite the gas by striking the spark-lighter in front of the tip.

2. Since the oxygen torch valve is closed, the acetylene is burned by the oxygen in the air. There is not sufficient oxygen to provide complete combustion, so the flame is smoky and produces a soot of fine unburned carbon. Continue to open the acetylene valve slowly until the flame burns clean. The acetylene flame is long, bushy, and has a yellowish color. This pure acetylene flame is unsuitable for welding.

3. Slowly open the oxygen valve. The flame changes to a bluish-white and forms a bright inner cone surrounded by an outer flame. The inner cone develops the high temperature required for welding.

**2.5 General Guidelines** – Similar to any other welding processes, the following procedure to be adopted for attaining the best results from the OAGW process.

1. Dirt, oil, and oxides can cause incomplete fusion, slag inclusions, and porosity in the weld metal. Contaminants must be removed along the joint and sides of the base metal.

2. The gas flow from the cylinders & the torch and leakage of any kind shall be properly controlled.

3. The root opening for a given thickness of metal should permit the gap to be bridged without difficulty and also to achieve full penetration. Specifications for root openings thus should be followed exactly.

4. Thin sheet metal is easily melted completely by the flame. Thus, edges with square faces can be butted-together and welded. Thickness below 3/16 in. (4.8 mm) is suitable for this kind of joint.

5. For thicknesses of 3/16 to 1/4 in. (4.8 to 6.4 mm), a slight root opening or groove is necessary for complete root penetration, but filler metal must be added to compensate for the opening.

6. Joint edges 1/4 in. (6.4 mm) and thicker should be beveled. Beveled edges at the joints provide a groove for better penetration and fusion at the sides.

7. The angle of bevel for oxyacetylene welding varies from 35 to 45 degrees, i.e., the included angle of the joint varies from 70 to 90 degrees, depending upon the application.

8. A root face 1/16 in. (1.6 mm) wide is often used. Plate thicknesses 3/4 in. (19 mm) and above are double beveled when welding can be done from both sides. The root face can vary from 0 to 1/8 in. (0 to 3.2 mm). Beveling both sides reduces the amount of filler metal required by approximately one-half. Gas consumption per unit length of weld is also reduced.

9. A square groove edge preparation is the easiest & most common. This edge is prepared by machining, chipping, grinding or by oxygen cut. The thin oxide coating on oxygen-cut surface need not be removed.

10. Air contains approximately 80 percent nitrogen by volume which does not support combustion. Fuel gases burned with air, therefore, produce lower flame temperatures

than those burned with oxygen. The air-fuel gas flame is thus suitable for welding light sections and for light brazing and soldering operations.

11. A range of tip sizes is provided for obtaining the required volume or size of welding flame which may vary from a short, small diameter needle flame to a flare 3/16 in. (4.8 mm) or more in diameter and 2 in. (51 mm) or more in length.

12. The inner cone or vivid blue flare of the burning mixture of gases issuing from the tip is called the working flare. The closer the end of the inner cone is to the surface of the metal being heated or welded, the more effective is the heat transfer from flame to metal. The flame can be made soft or harsh by varying the gas flow. Too low a gas flow for a given tip size will result in a soft, ineffective flame sensitive to backfiring. Too high a gas flow will result in a harsh, high velocity flame that may blow the molten metal from the puddle.

13. The chemical action of the flame on a molten pool of metal can be altered by changing the ratio of the volume of oxygen to acetylene issuing from the tip. Most oxyacetylene welding is done with a neutral flame having approximately a 1:1 gas ratio. An oxidizing action can be obtained by increasing the oxygen flow, and a reducing action will result from increasing the acetylene flow.
14. Preheating of the job shall be done first for gas-cutting operation. Once the material is heated up, flow of oxygen is increased to force the oxidation reaction & cutting.

## 3.0 SALIENT FEATURE OF THE PROCESS:

1. Welder can control the welding process over the rate of heat input, the temperature of the weld zone, and the oxidizing or reducing potential of the welding atmosphere.

2. Weld bead size and shape and weld puddle viscosity are also controlled in the welding process because the filler metal is added independently of the welding heat source.

3. Gas welding is ideally suited to the welding of thin sheet, tubes, and small diameter pipe. It is also used for repair welding.

4. However, thick section welds, except for repair work, are not economical.